CONSTANTS AND FORMULAS

FORMULA FOR $\bar{X}$ AND R CHARTS

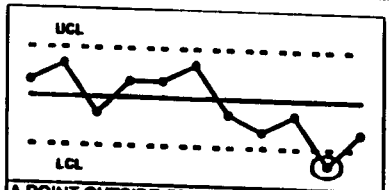
$\bar{X}$ - Chart	R - Chart
$\bar{\bar{X}} = \frac{\Sigma X}{n}$	$CL_R = \bar{R} = \frac{\Sigma R}{k}$
$CL_{\bar{X}} = \bar{\bar{X}} = \frac{\Sigma \bar{X}}{k}$	$UCL_R = D_4 \times \bar{R}$
$UCL_{\bar{X}} = \bar{\bar{X}} + (A_2 \times \bar{R})$	$LCL_R = D_3 \times \bar{R}$
$LCL_{\bar{X}} = \bar{\bar{X}} - (A_2 \times \bar{R})$	$\hat{\sigma} = \frac{\bar{R}}{d_2}$
$Cp = \frac{USL - LSL}{6\hat{\sigma}}$	
$Cpk = \text{minimum of } \frac{USL - \bar{\bar{X}}}{3\hat{\sigma}} \text{ or } \frac{\bar{\bar{X}} - LSL}{3\hat{\sigma}}$	

CONTROL CHARTS FOR VARIABLE DATA

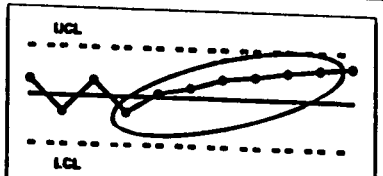
x	Individual Measurement
$\bar{x}$	Subgroup Average
$\bar{\bar{x}}$	Grand Average
Σ	Sum of
R	Range = Highest Value - Lowest Value
CL	Center Line
UCL	Upper Control Limit
LCL	Lower Control Limit
k	Number of Subgroups
n	Subgroup Size
$\hat{\sigma}$	Process Standard Deviation
A_2	Factor for $\bar{x}$ Chart Limits
D_4	Factor for UCL on R Chart
D_3	Factor for LCL on R Chart
USL	Upper Specification Limit
LSL	Lower Specification Limit
d_2	Factor for estimating Process Standard Deviation

Chart X	
n Subgroup Size	A2 Upper and Lower Control Limit Factor
2	1.880
3	1.023
4	0.729
5	0.577
6	0.483
7	0.419
8	0.373
9	0.337
10	0.308
11	0.285
12	0.266
13	0.249
14	0.235
15	0.223
16	0.212
17	0.203
18	0.194
19	0.187
20	0.180
21	0.173
22	0.167
23	0.162
24	0.157
25	0.153

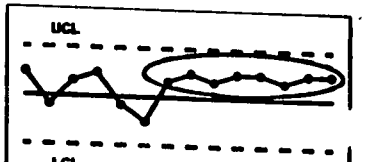
Range Chart R			
n Subgroup Size	d2 Estimate of Standard Deviation Divisor	D3 Lower Control Limit Factor	D4 Upper Control Limit Factor
2	1.128	na	3.270
3	1.693	na	2.574
4	2.059	na	2.282
5	2.326	na	2.114
6	2.534	na	2.004
7	2.704	0.076	1.924
8	2.847	0.136	1.864
9	2.970	0.184	1.816
10	3.078	0.223	1.777
11	3.173	0.256	1.744
12	3.258	0.283	1.717
13	3.336	0.307	1.693
14	3.407	0.328	1.672
15	3.472	0.347	1.653
16	3.532	0.363	1.637
17	3.588	0.378	1.622
18	3.640	0.391	1.608
19	3.689	0.403	1.597
20	3.735	0.415	1.585
21	3.778	0.425	1.575
22	3.819	0.434	1.566
23	3.858	0.443	1.557
24	3.895	0.451	1.548
25	3.931	0.459	1.541



A POINT OUTSIDE OR DIRECTLY ON THE CONTROL LINE



A TREND OF 7 CONSECUTIVE POINTS MOVING IN THE SAME DIRECTION, EITHER UPWARD OR DOWNWARD INDICATES A GRADUAL CHANGE IN THE PROCESS



SEVEN POINTS ABOVE THE CENTRAL LINE INDICATE THAT THE CENTER OF THE NORMAL DISTRIBUTION HAS STARTED UPWARD

CONSTANTS AND FORMULAS